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# Fifth Annual Conference on Carbon Capture & Sequestration

## *Steps Toward Deployment*

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### *Program*

## **U.S. DOE Carbon Capture and Separation Program: A Technology Development Program with a Commercialization Focus**

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U.S. DoE National Energy Technology Laboratory

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# Outline

- **DOE CO<sub>2</sub> Capture Program Objectives.**
- **How Do We Determine the True CO<sub>2</sub> Capture Market ?**
- **What is the CO<sub>2</sub> Capture Market ?**
- **Why the Need to Focus on CO<sub>2</sub> Capture Program Objectives?**
- **What are the Possible Implications for Certain Industries ?**
- **Closing Thoughts**



## Disclaimer

- **The results of this market data analysis are based on limited data and not to be:**
  - Considered as existing or new DOE policy related in anyway directly or indirectly to the Sequestration Program or Office of Fossil Energy and NETL programs.
  - Utilized as forecasting other than its representation of the underlying data which is publicly available.
  - Used to imply the possible direction for regulations.
  - Used to definitively identify which units will and won't adopt CO<sub>2</sub> capture technology.
- **The intended purpose of this market data analysis is to provide some insight on where to focus CO<sub>2</sub> Capture R&D to ensure a sector of the market likely to adopt CO<sub>2</sub> capture technologies have them available should they be needed.**



# CO<sub>2</sub> Capture and Separation Program Objectives

- **90% Capture of CO<sub>2</sub> from a treated gas stream**
- **2007 Goal:**
  - Post-Combustion including Oxy-combustion:
    - Develop at least two (2) capture technologies that each result in less than a **45%** increase in the cost of energy services.
  - Pre-Combustion Capture and Separation Technologies:
    - Develop at least two (2) capture technologies that each result in less than a 20% increase in the cost of energy services.
- **2012 Goal:**
  - Post-Combustion including Oxy-combustion:
    - Develop at least two (2) capture technologies that each result in less than a **20%** increase in the cost of energy services.
  - Pre-Combustion Capture and Separation Technologies:
    - Develop at least two (2) capture technologies that each result in less than a 10% increase in the cost of energy services
- **Reduce GHG intensity by 18% per GDP. (Source: Clear Skies Initiative)**



# How Do We Plan to Achieve these Objectives

- **Diversified Project Portfolio:\***

- 10 Pre-Combustion Projects,
- 19 Post-Combustion, and
- 10 Oxy-Combustion

Focus of this Presentation

- **A ‘Capture R&D Plan’ that has a commercialization focus.**

- **Management Approach that fully utilizes the resources available to NETL internally and externally.**



\*Includes OSER, HBCU, UCR, and SBIR

# How Do We Determine the True CO<sub>2</sub> Capture Market in the U.S.

- **Through a CO<sub>2</sub> Capture R&D Plan comprised of 3 discrete tasks**
  - Technology Gap Analysis
  - Project Portfolio Assessment
  - Acquisition Strategy
- **With a Focused Management Approach**
- **Objective:**
  - Identify which units are most likely to adopt CO<sub>2</sub> capture technology under a regulated environment.
  - Identify a clear path for R&D that meets defined market segments in order to maximize program funding levels.
  - Identify a path to achieving program objectives and targets.



# CO<sub>2</sub> Capture Market Data Analysis

## Assumptions

- Sources for the data analysis are:
  - EPA Clean Air Markets Database
  - Form EIA-767, EIA-860, and EIA- 423 Databases
  - Annual Energy Outlook 2006
- 90% of the CO<sub>2</sub> from the treated gas stream is capture for both new and retrofit units.
- Existing capacity operates at a 70% capacity factor.
- New capacity operates at an 80% capacity factor
- New capacity uses coal in the same ratio as existing capacity (tons of coal/MW capacity).
- Cost of new capacity is \$2,000/kW and CO<sub>2</sub> retrofit technology is \$1,084/kW.\*

Source: Engineering Feasibility and Economics of CO<sub>2</sub> Capture on an Existing Coal Fired Power Plant, 6/2001; Alstom Power.



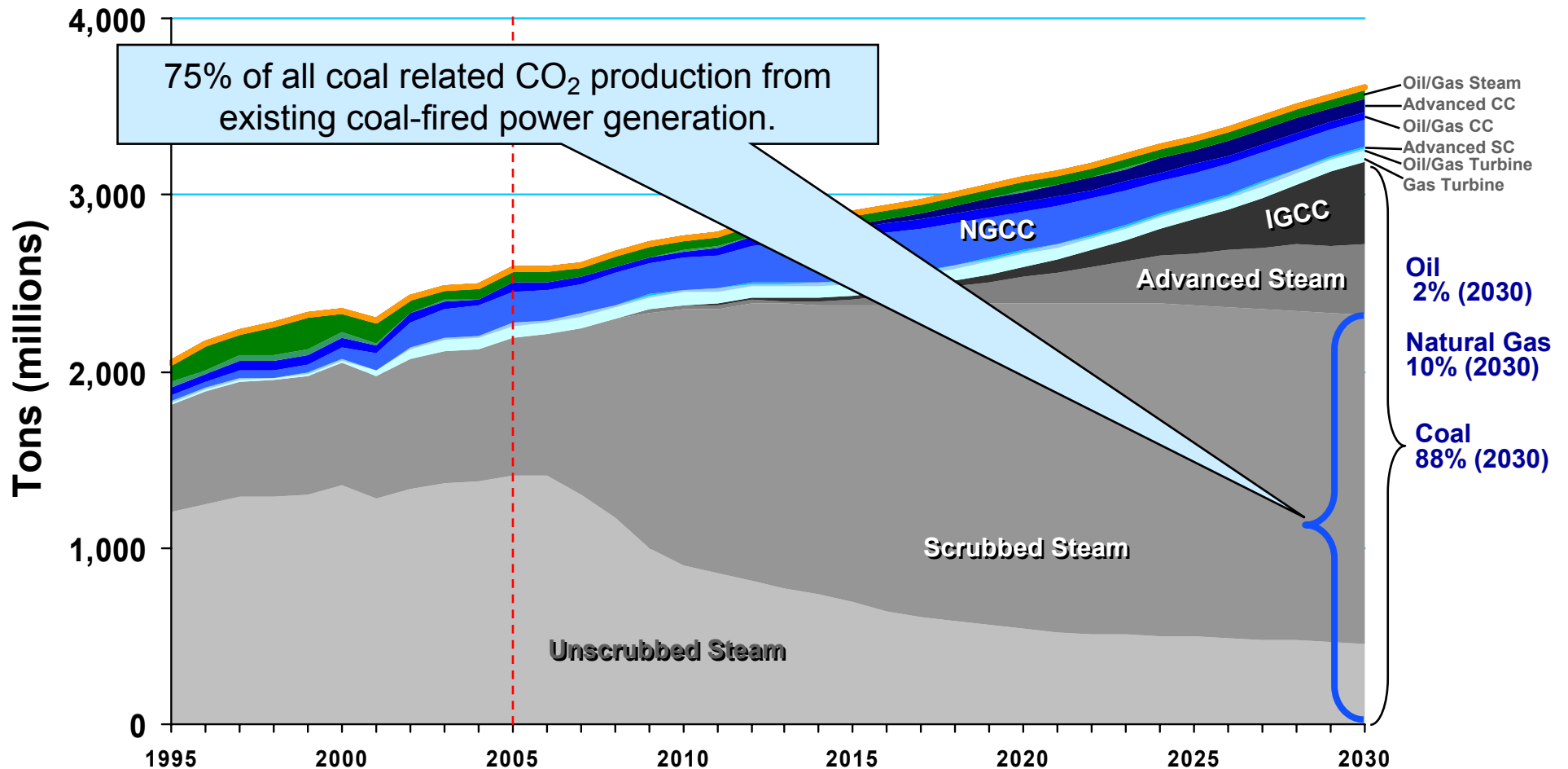
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## CO<sub>2</sub> Capture Assumptions

- Calculations are based on all the units in the identified market segment installing CO<sub>2</sub> capture technology.
- Cap and Trade Schemes, Carbon Tax or other forms of legislation are not considered.
- Corporate and financial strategic determinations that would be involved under normal business conditions are not within the scope of this market data analysis.



# What is the CO<sub>2</sub> Capture Market ?

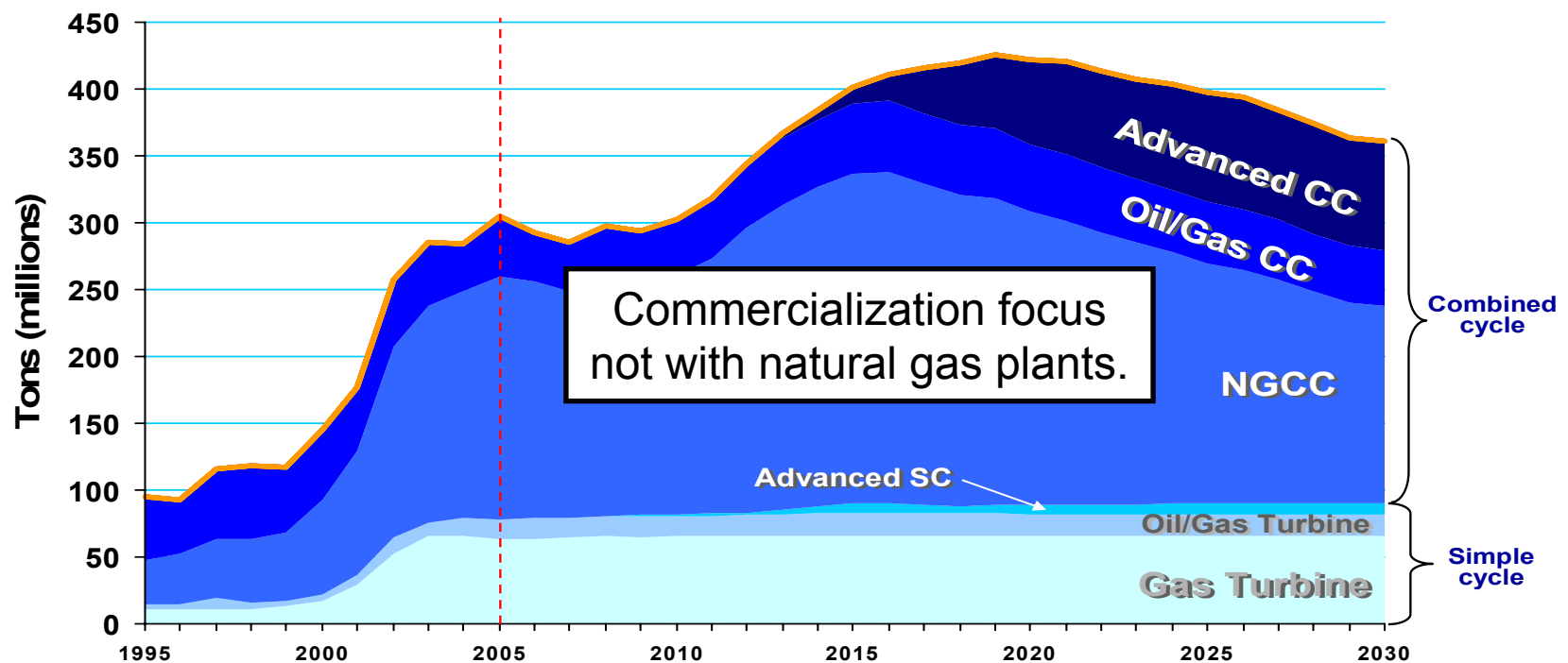


*Coal Dominates CO<sub>2</sub> Emissions From Fossil Power Generation  
As Percent of Coal-fired Generation Grows to 59% (2030)*



# CO<sub>2</sub> FROM GAS TURBINE CAPACITY FORECAST AEO'06

- NGCC Capacity Factor (CF) in 2013 forecasted at 40% and 32% in 2030.

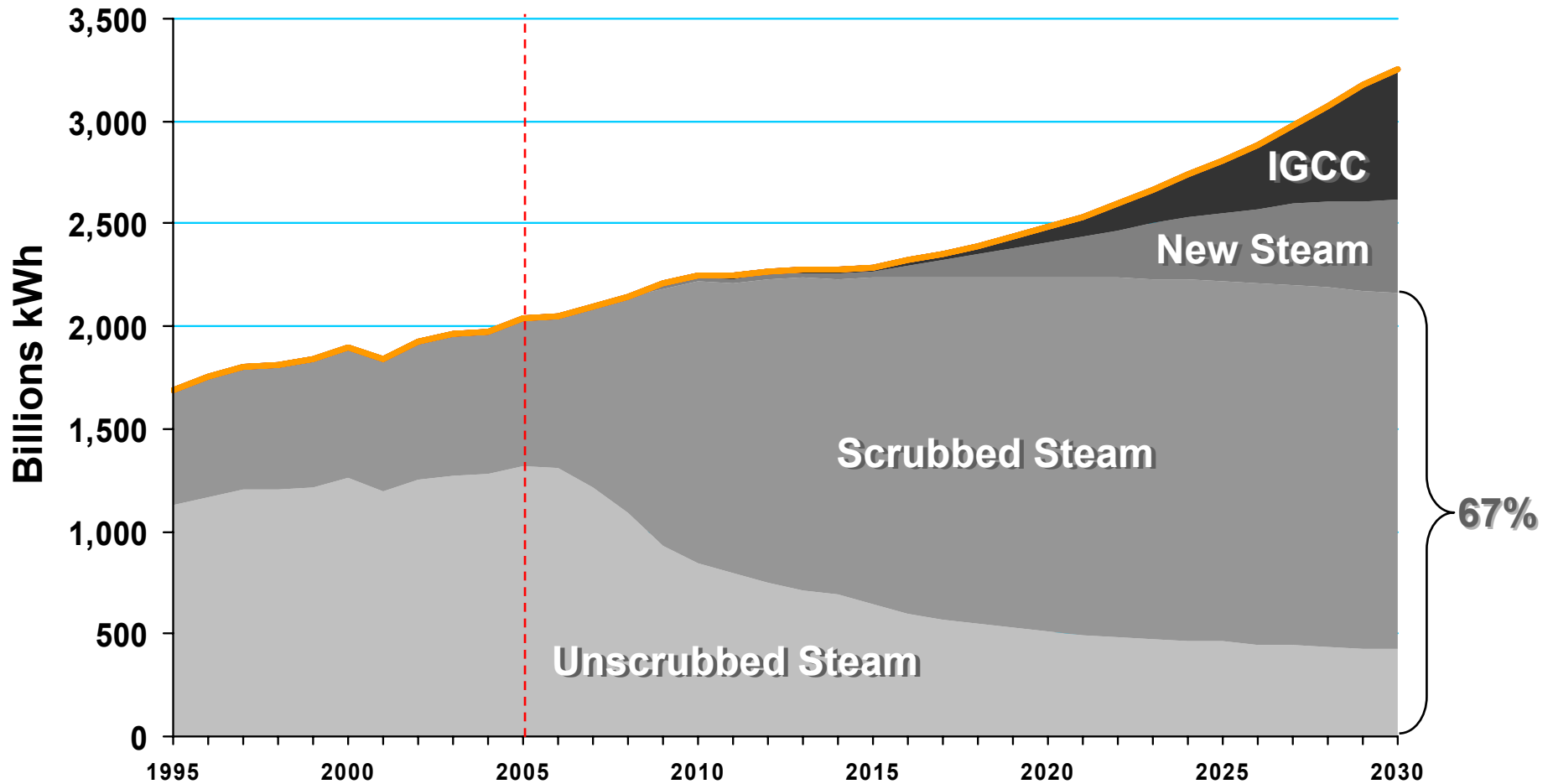


*Declining Gas Turbine kWh and CO<sub>2</sub> After 2019*

- Simple Cycle CF in 2013 forecasted at 13% and 11% in 2030.



## kWh From Coal Capacity Forecast AEO'06E

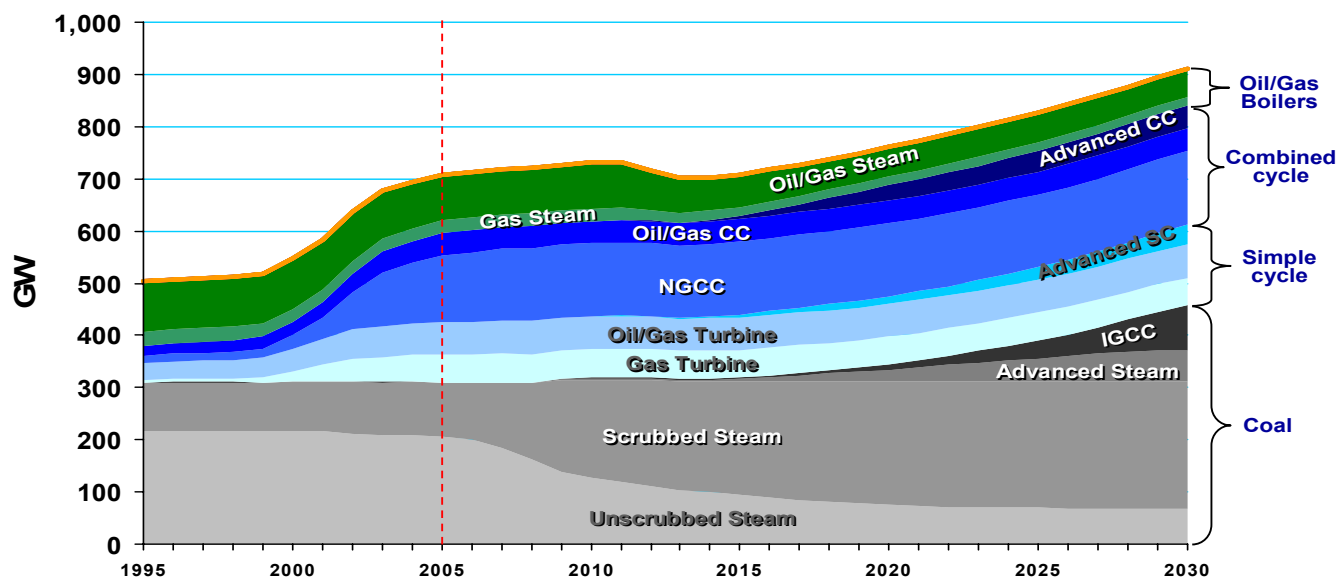


*Large Proportion of Total Coal-fired kWh From Existing Plants*



# What is the CO<sub>2</sub> Capture Market ?

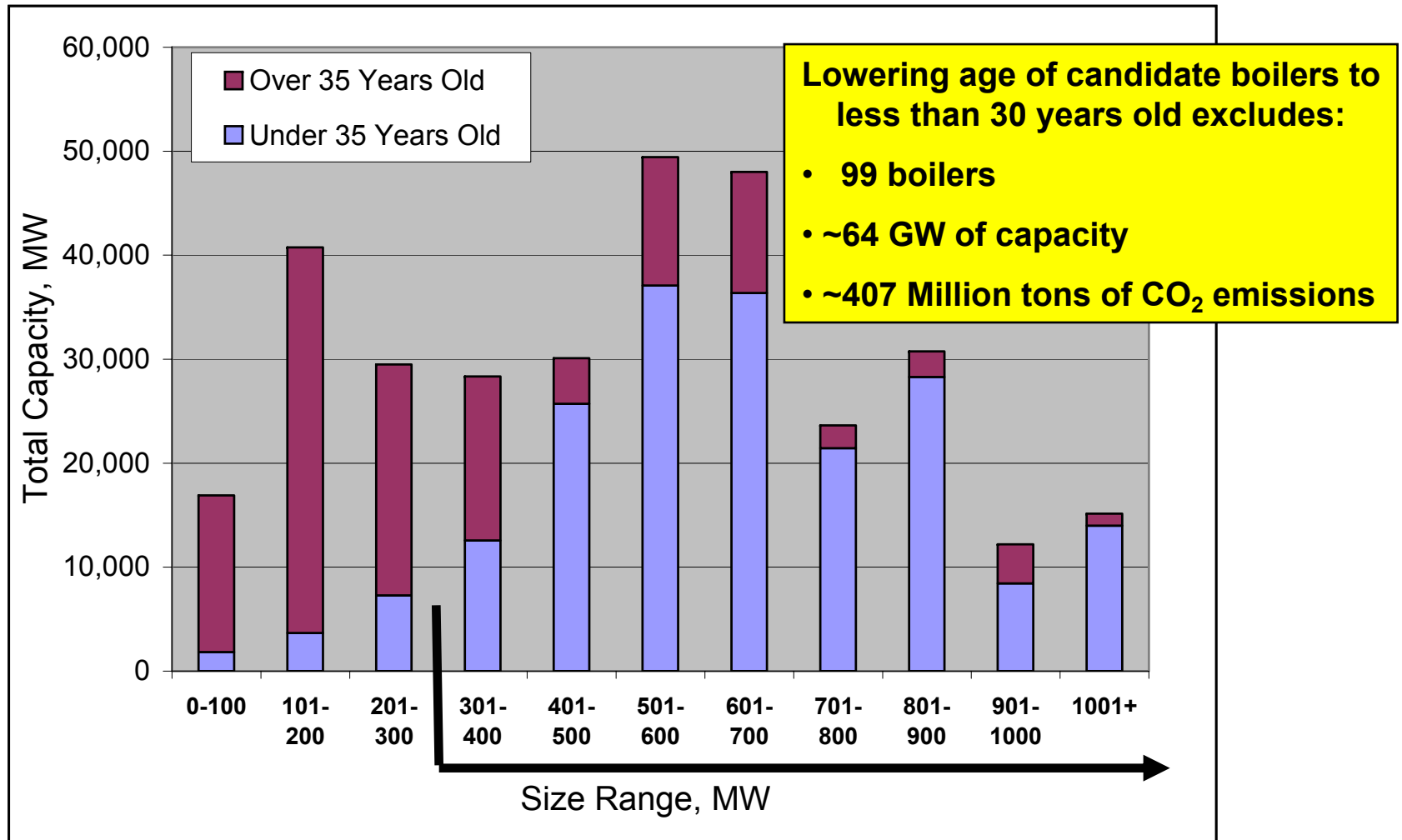
- Total 9,877 units installed in the U.S.
  - 337 GW of coal-fired units
  - 422 GW of gas-fired units
  - 64 GW of oil-fired units
- 423 existing coal-fired power plants
  - Comprise of 1,089 boiler units
  - Generate 323 GW (Phase 1&2)
  - Emit 1,917.2 million metric tons of CO<sub>2</sub>



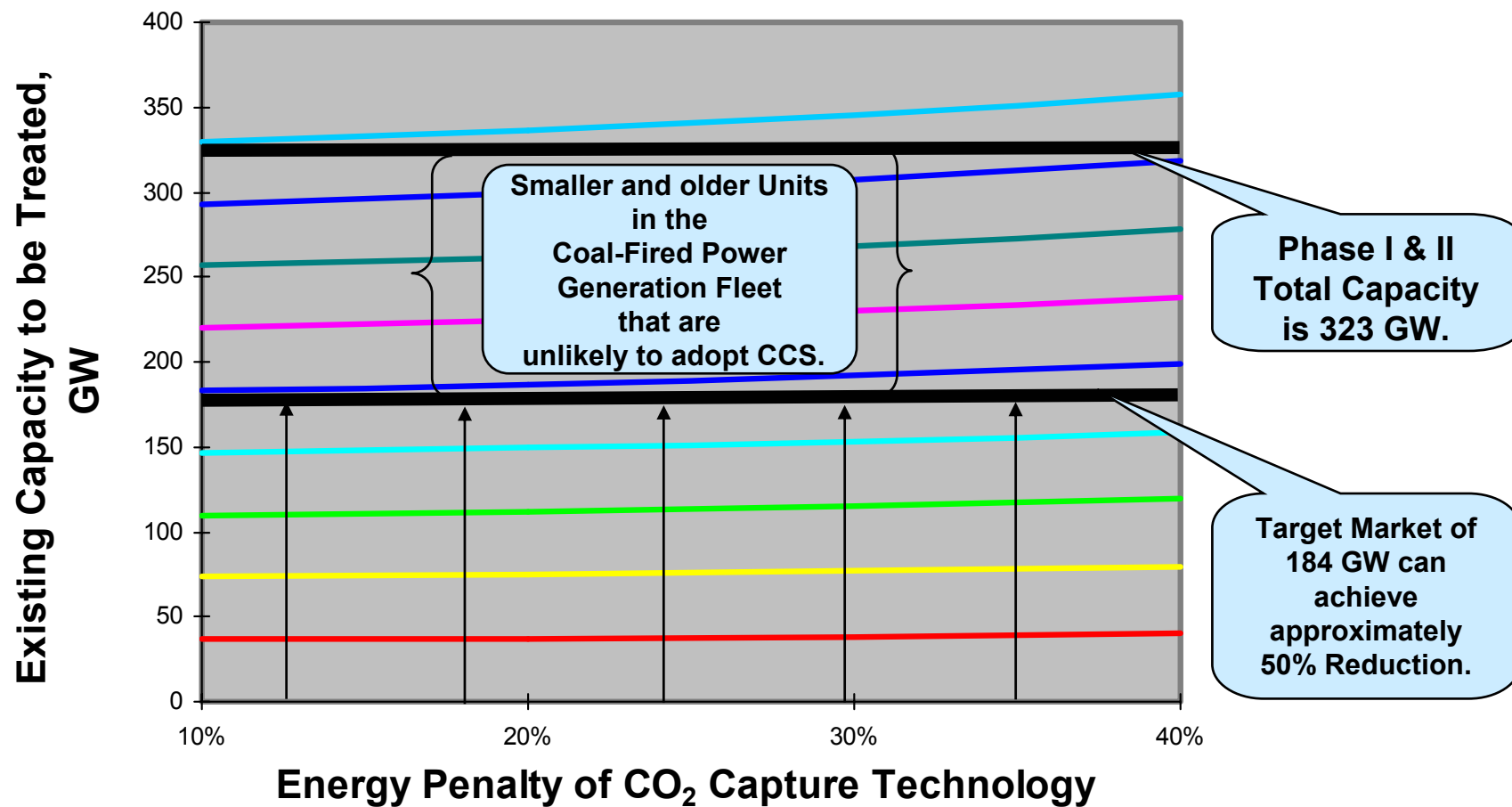
*Fossil Power Generation Technology Types*

Who is the customer so that there is a focus for Capture R&D?

# Power Market Sector Most Likely to Adopt CCS



# Maximum CO<sub>2</sub> Percent Reduction Goals for the Phase I & II Coal Fired Power Sector



# Why the Need to Focus on the CO<sub>2</sub> Capture Program Objectives

Energy Penalty due to CO <sub>2</sub> Capture	10%	20%	30%	40%
Target Market, GW	184	184	184	184
Fleet CO <sub>2</sub> Reduction, %	50.2	49.2	47.9	46.3
New Capacity Req'd, GW	25.5	57.5	98.5	153.3
Additional Coal Req'd., tons x 10 <sup>3</sup>	79,940	179,864	308,338	479,637
Cost of New Capacity, MM\$	45,975	103,444	177,332	275,850
Cost of CO <sub>2</sub> Retrofits, MM\$	91,950	91,950	91,950	91,950
<b>Total New Cost, MM\$</b>	<b>137,925</b>	<b>195,394</b>	<b>269,282</b>	<b>367,800</b>

**Need for further R&DD to minimize the cost and externalities impact due to CO<sub>2</sub> Capture and Storage.**

Current Energy Penalty of CO<sub>2</sub> BACT MEA Absorption System

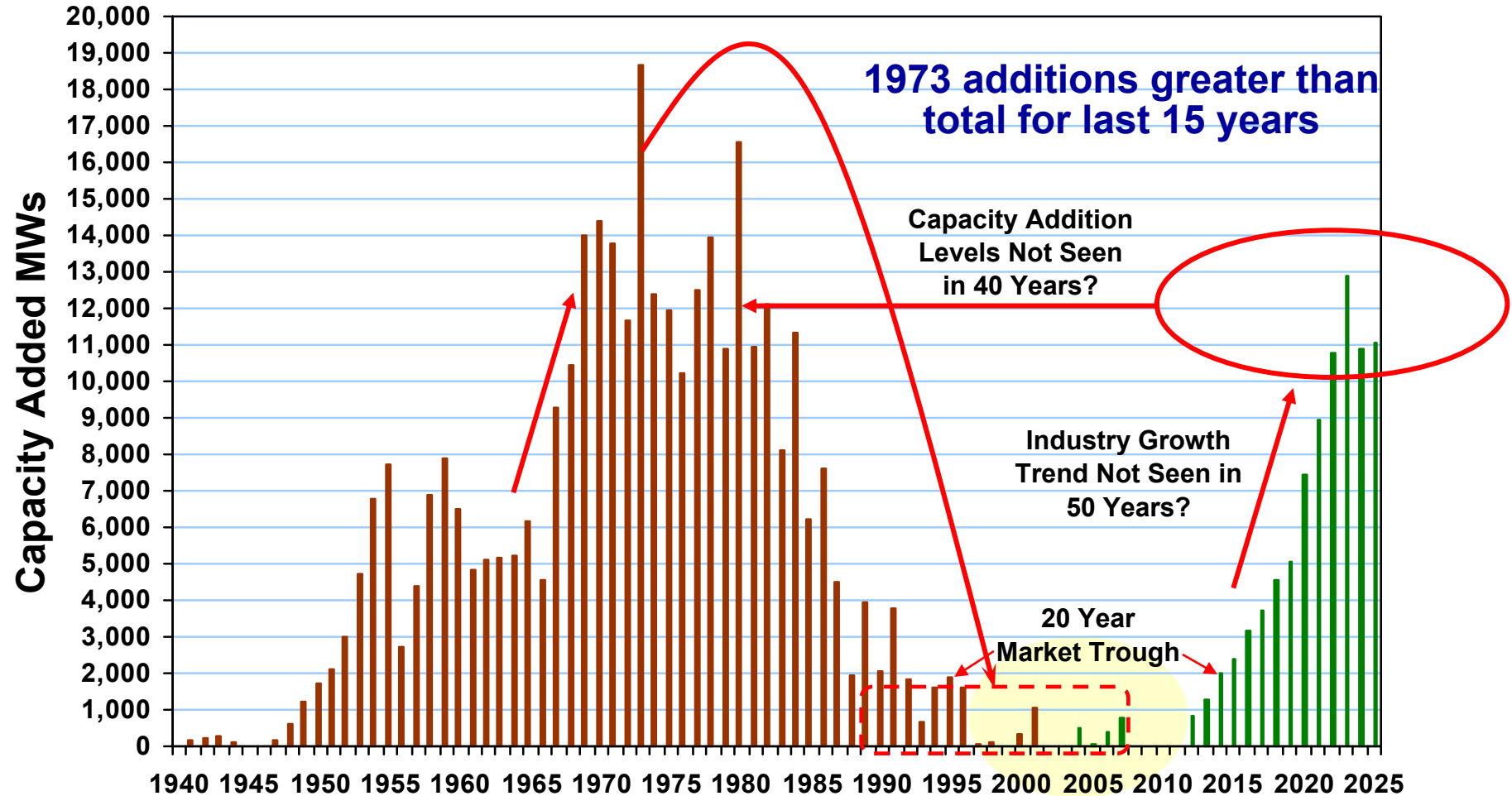


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# **What are the Possible Implications for Certain Industries Tied to the CO<sub>2</sub> Capture Market ?**



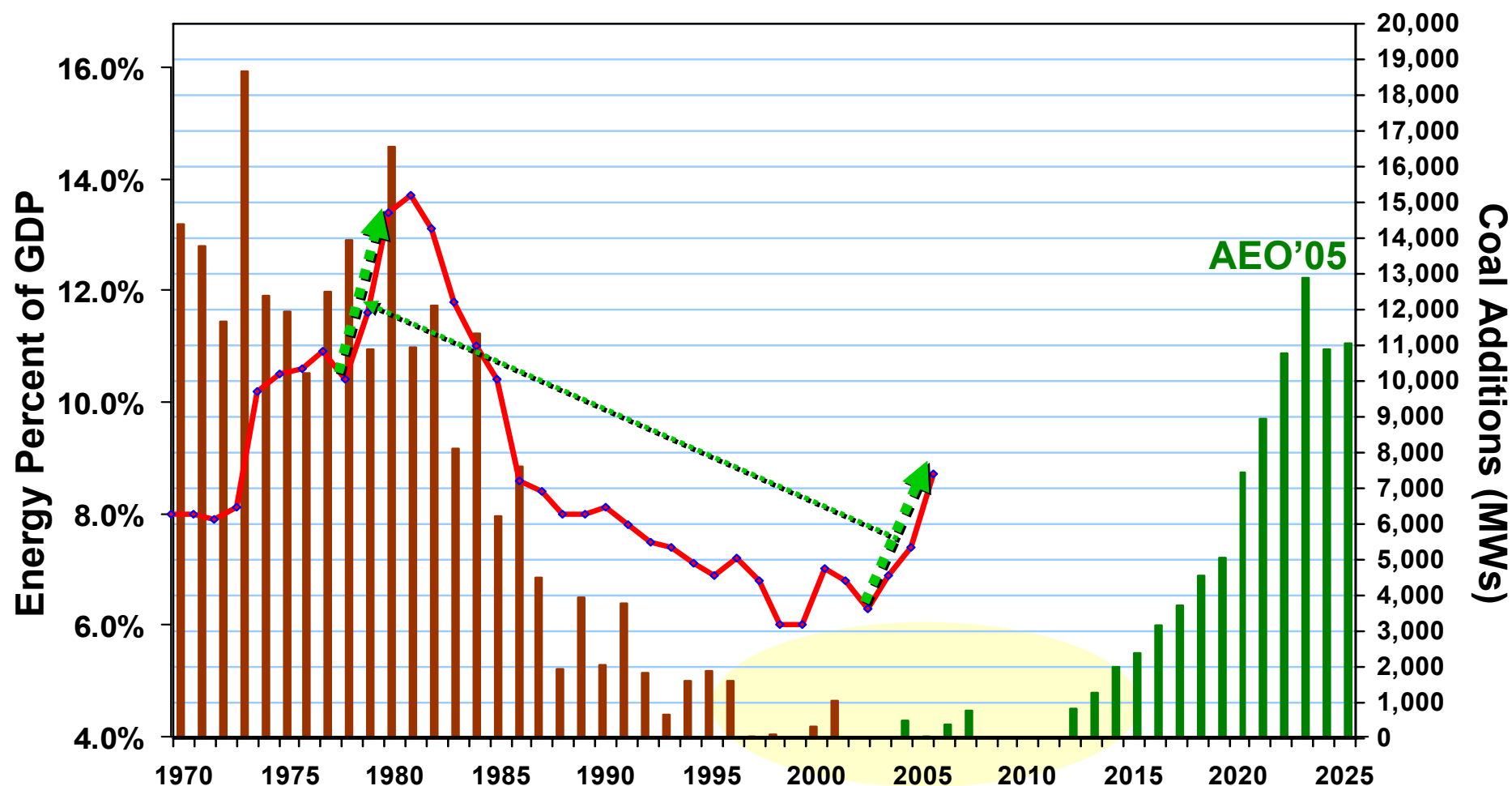
# Coal Capacity History and Forecast AEO'05



*Will the Nation's Industry be Prepared and Capable  
of Meeting This Coal Plant Forecast?*



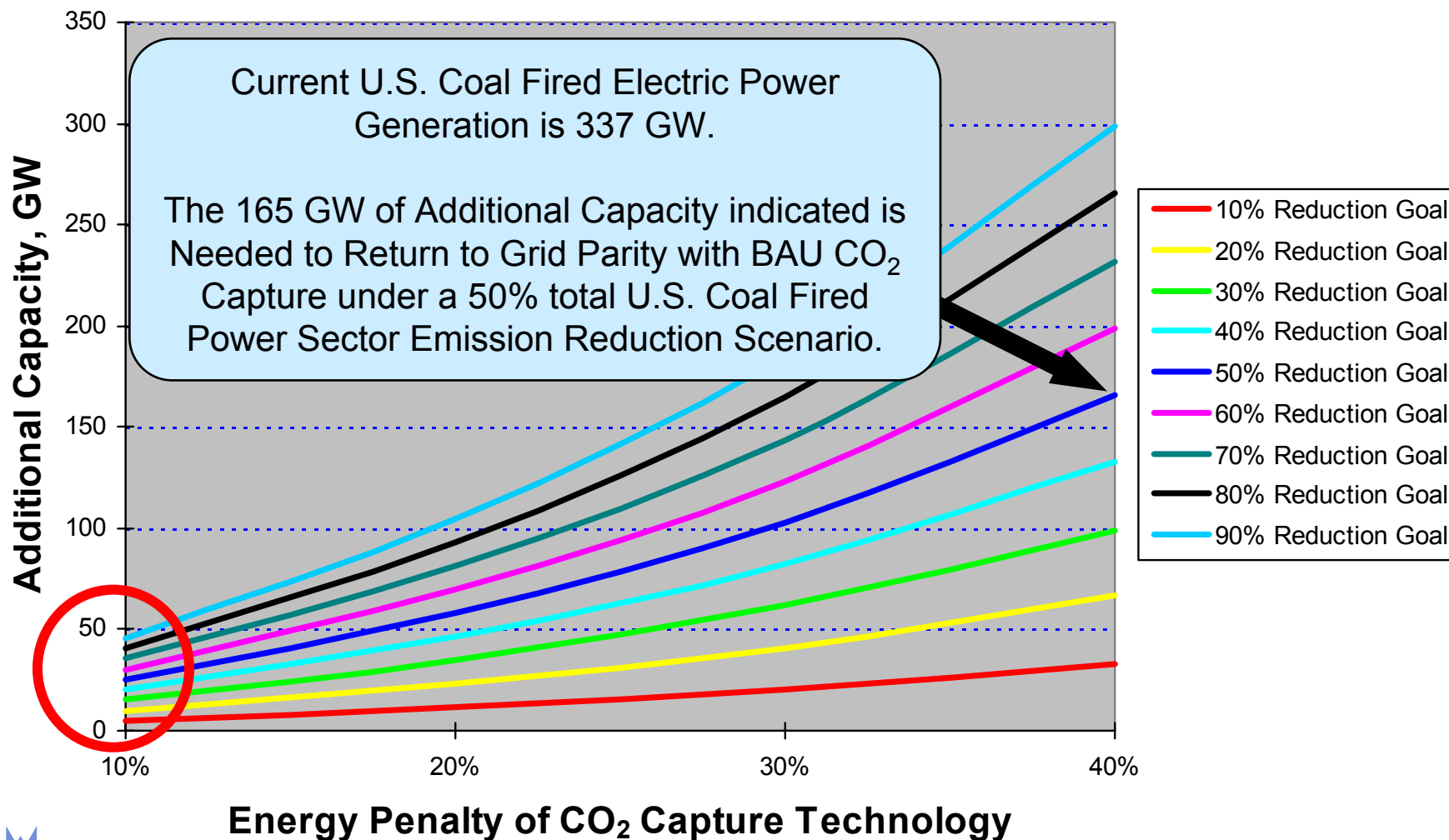
# Difference In Industry's Capacity to Serve



*This Time The Domestic Coal-fired Industry Not Entrenched and Thriving*



# Additional Capacity Required to meet Increased Targets for CO<sub>2</sub> Emission Reduction



# As Utilities Seek More Coal, Railroads Struggle to Deliver

- **Utilities report low coal supplies due to delayed railway shipments**
  - May 2005 rail disruptions in WY delayed shipments from Powder River Basin (20 million tons) cutting supplies at coal plants
  - Utilities estimate Powder River Basin delays cost the industry \$3 billion
- **Consolidation and surges in freight fuel fears that railroads can't handle growing coal demand**
- **Utilities seeking Congressional hearings on coal-delivery problems**
  - May ask for reliability standards for railroads from Surface Transportation Board
- **Utilities also report higher rail rates between 20% and 100%**

## THE WALL STREET JOURNAL.

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### Taking Lumps

### As Utilities Seek More Coal, Railroads Struggle to Deliver

Snags in Wyoming Ripple  
Through Taxed Network;  
Power Plants Run Short

#### A 5,833-Hopper-Car Deficit

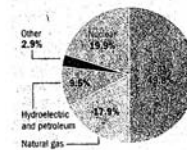
By REBECCA SMITH  
And DANIEL MACHALABA

During the past 10 months, Arkansas Electric Cooperative Corp. has been forced to do things that power generators hate to do: It cut electricity production at plants that are the cheapest to operate and ran its costliest units harder than ever. At times, it even bought electricity on the open market at top prices.

The electricity co-op made these moves because it is afraid of running out of coal. That's surprising in a country with such vast domestic reserves that some dub it the "Saudi Arabia of coal." But Arkansas Electric has a problem that is a growing concern for many U.S. utilities: It can't get enough coal to run its power plants because the trains that serve as its supply line aren't running on time. Delays in coal shipments to the Arkansas generator began last May with rail disruptions in Wyoming and forced the utility to burn more natural gas, lifting its 2005 power-generation costs by 21%, or \$100 million.

### Electric Mix

Breakdown of U.S. power generation  
by fuel type, 2004:



Source: Energy Information Administration

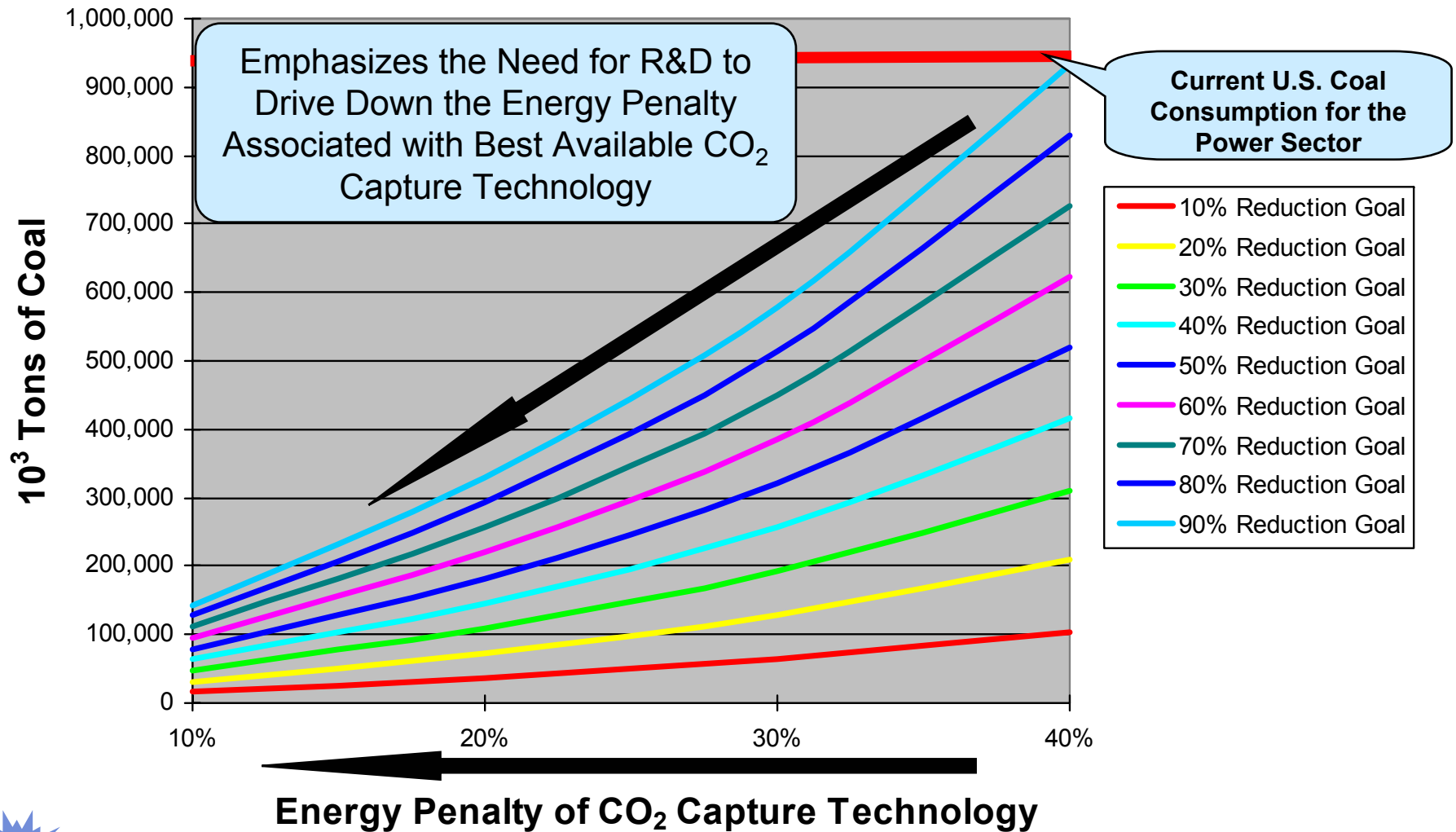
the nation's most important coal-producing regions. The delays have cut into fuel supplies at many coal-fired power plants around the country. In some cases, supplies are perilously low.

Now, the utilities are pouncing on the delays and a longstanding beef over concentrated ownership of rail routes, which crimps competition. Major utilities are asking members of Congress to hold hearings on the coal-delivery problems. They may ask Congress to direct the federal regulator, the Surface Transportation Board, to establish reliability standards for railroad deliveries and enforce them

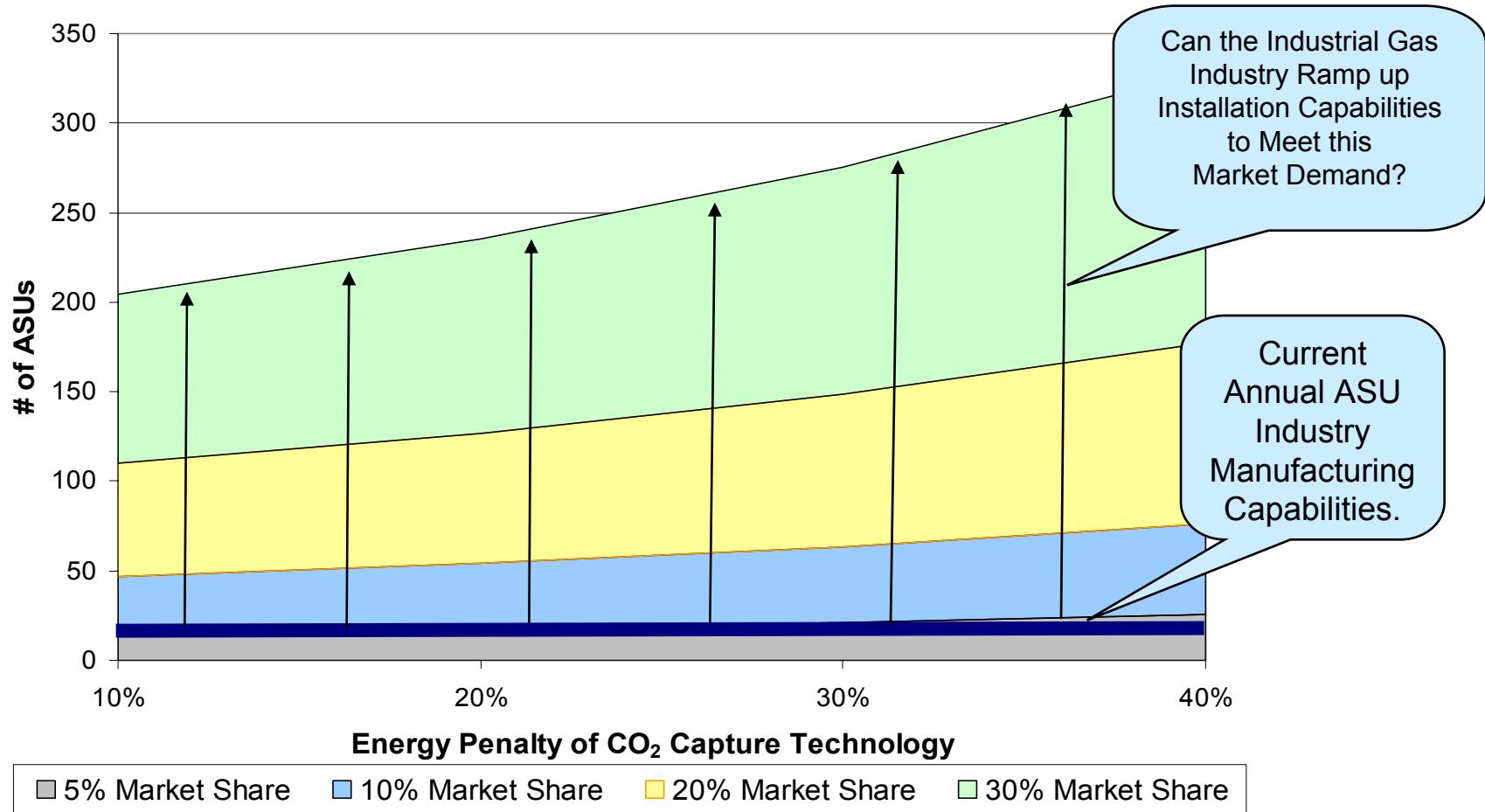
**Printed: March 15, 2006**



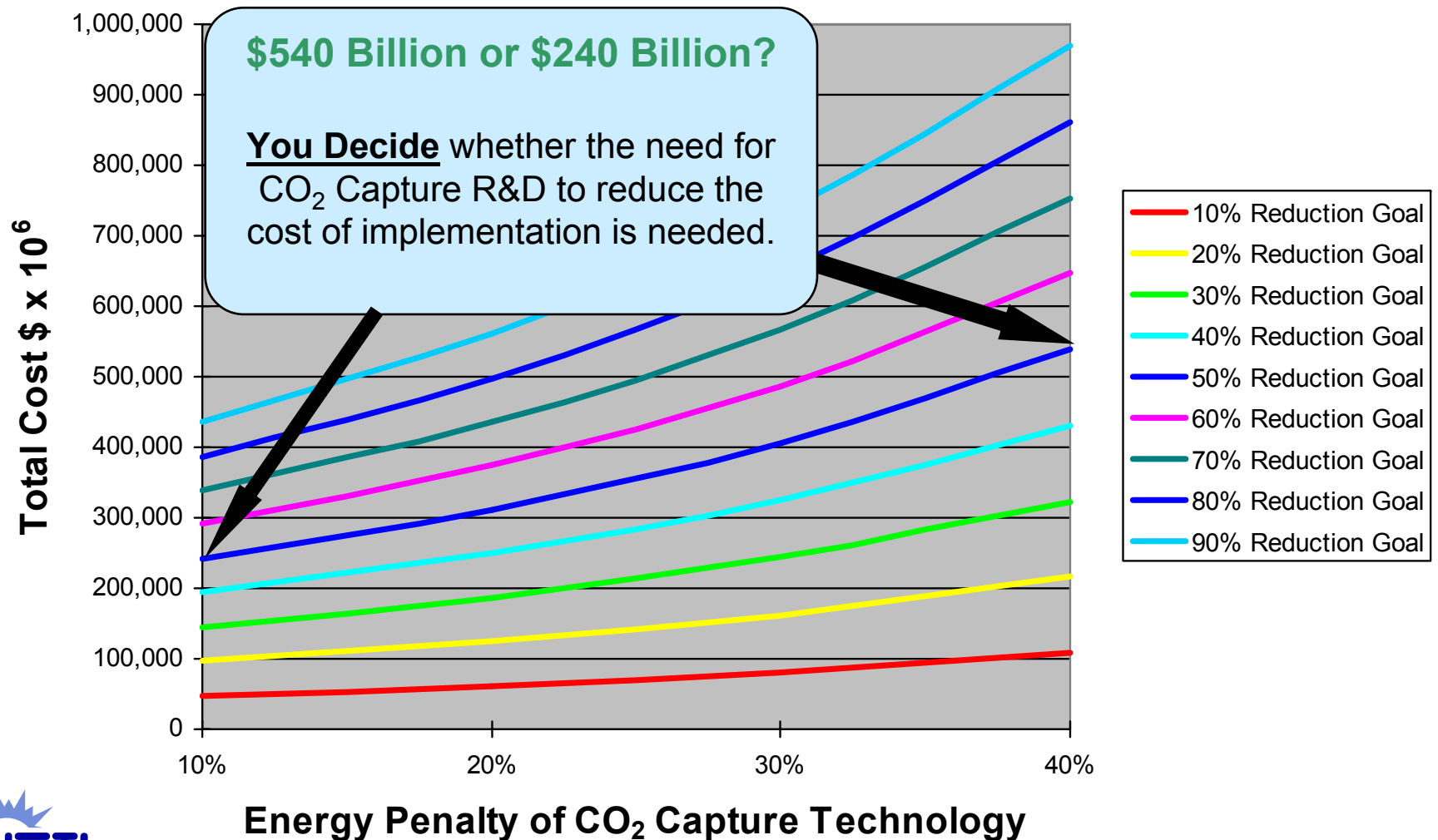
# Additional Coal Requirements to meet Increased Targets for CO<sub>2</sub> Emission Reduction



# Market Potential for ASUs Based on Retrofit and Capacity Addition with OxyCombustion



# Total Cost Associated with Retrofitting the Existing Fleet with a CO<sub>2</sub> Capture Plant to meet Increased CO<sub>2</sub> Emission Reduction Targets



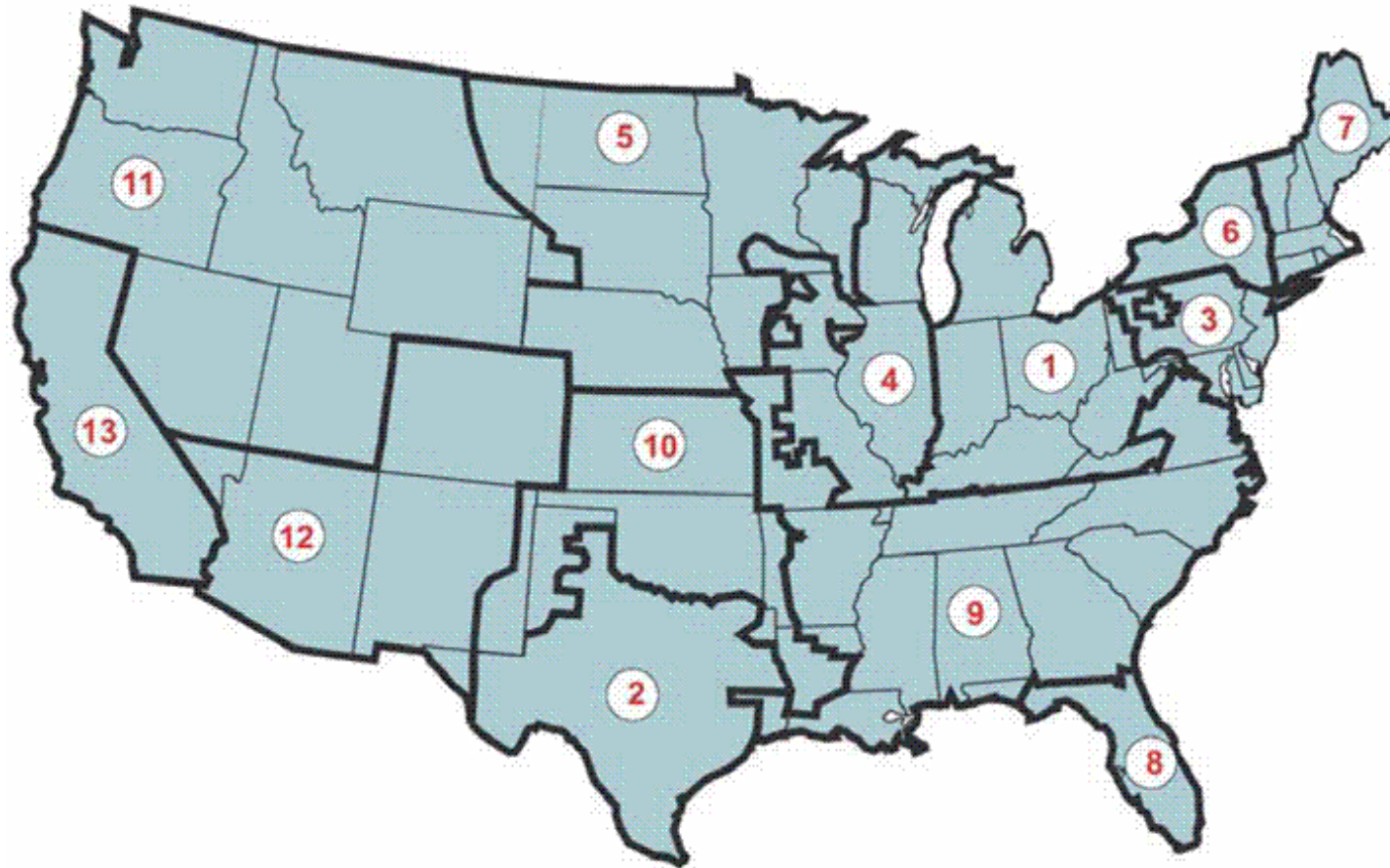
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# Where Are the CO<sub>2</sub> Emission Concentrations? 2005 – 2030



# NEMS Electricity Market Module

## Regional Designations

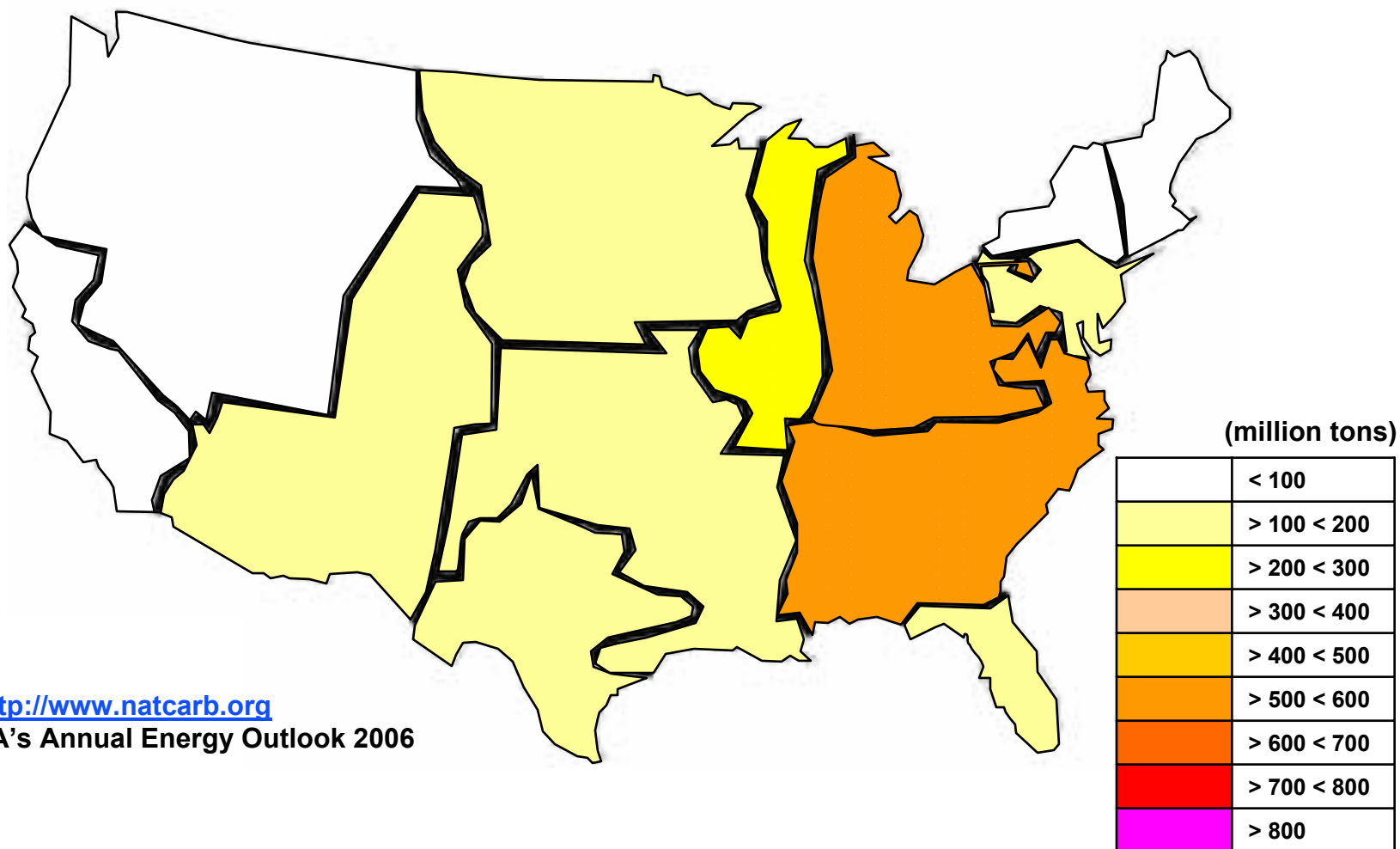


- 1 East Central Area Reliability Coordination Agreement (ECAR)
- 2 Electric Reliability Council of Texas (ERCOT)
- 3 Mid-Atlantic Area Council (MAAC)
- 4 Mid-America Interconnected Network (MAIN)
- 5 Mid-Continent Area Power Pool (MAPP)
- 6. New York (NY) Southern Nevada (RA)
- 7. New England (NE)

- 8 Florida Reliability Coordinating Council (FL)
- 9 Southeastern Electric Reliability Council (SERC)
- 10 Southwest Power Pool (SPP)
- 11 Northwest Power Pool (NWP)
- 12. Rocky Mountain Power Area, Arizona, New Mexico,
- 13 California (CA)



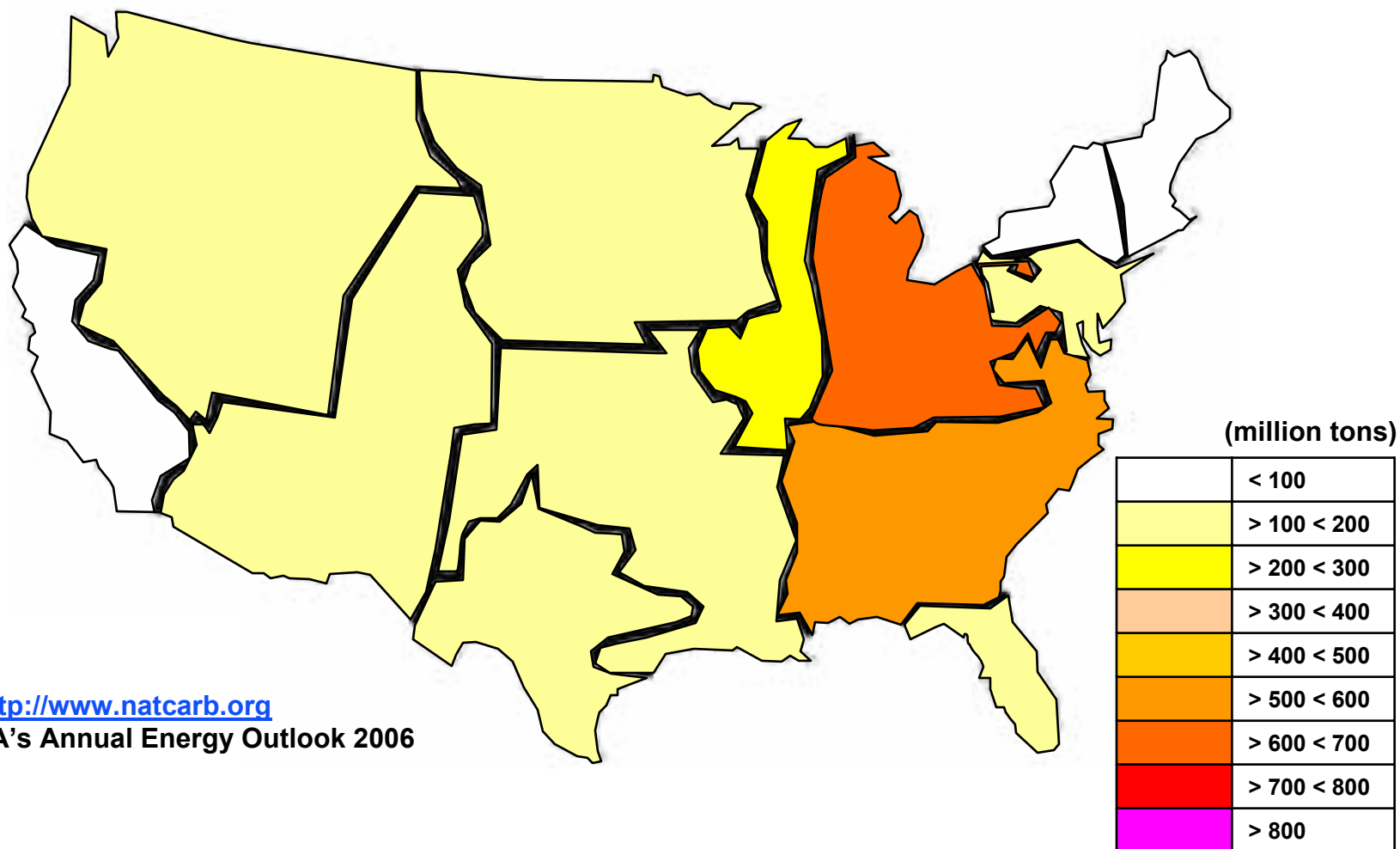
## 2005 CO<sub>2</sub> Forecast



Source: <http://www.natcarb.org>  
:EIA's Annual Energy Outlook 2006



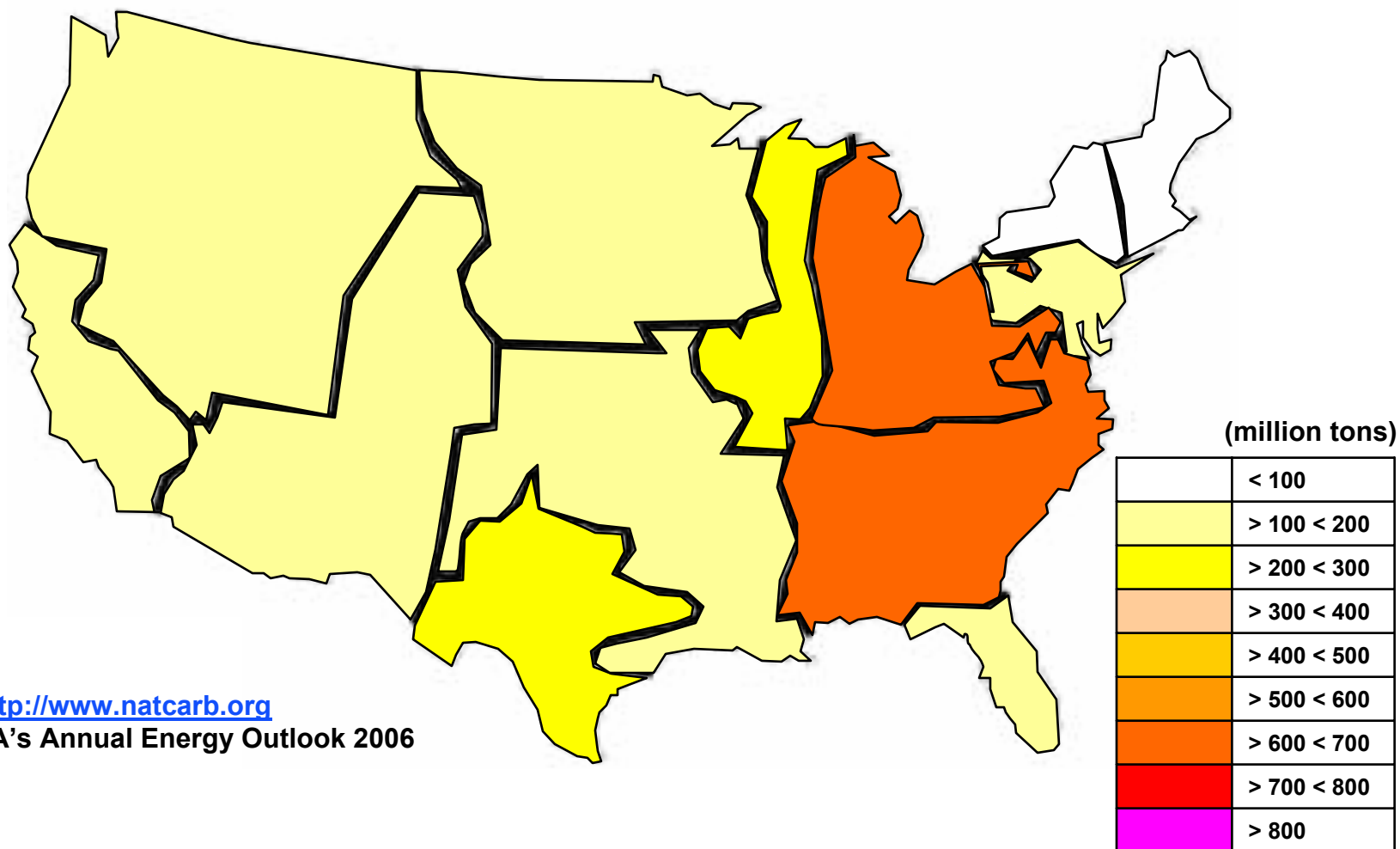
# 2010 CO<sub>2</sub> Forecast



Source: <http://www.natcarb.org>  
:EIA's Annual Energy Outlook 2006



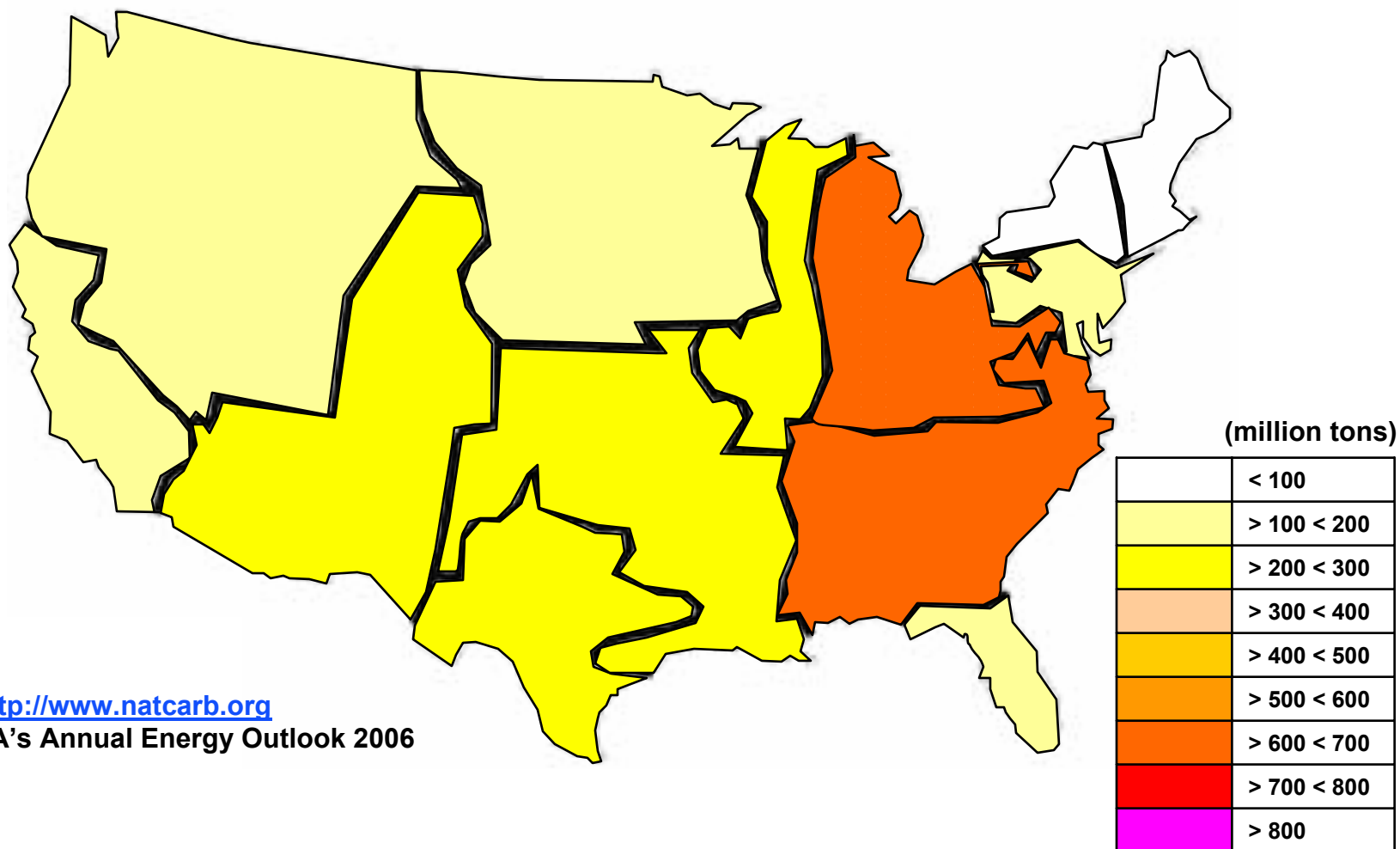
# 2015 CO<sub>2</sub> Forecast



Source: <http://www.natcarb.org>  
:EIA's Annual Energy Outlook 2006



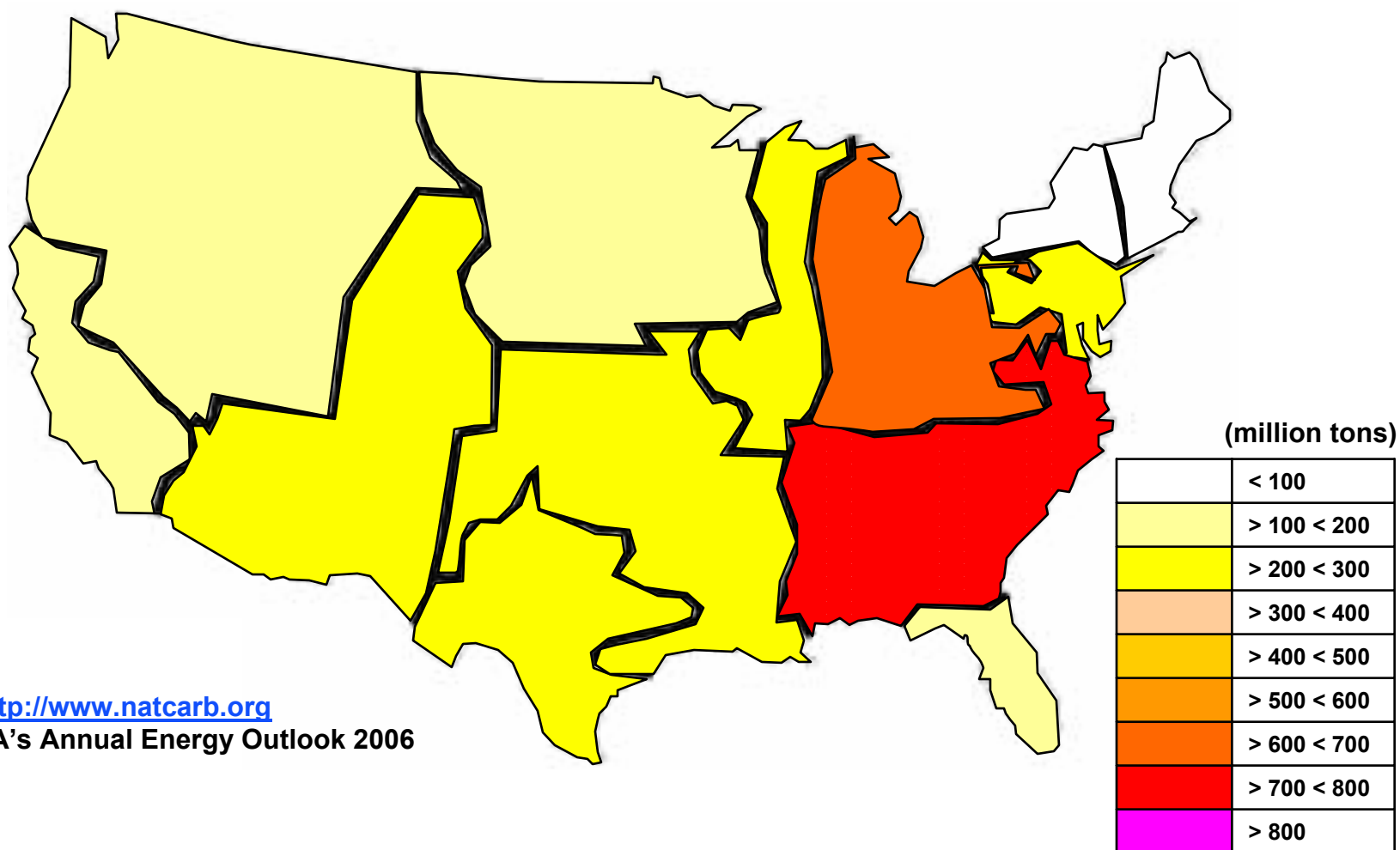
## 2020 CO<sub>2</sub> Forecast



Source: <http://www.natcarb.org>  
:EIA's Annual Energy Outlook 2006



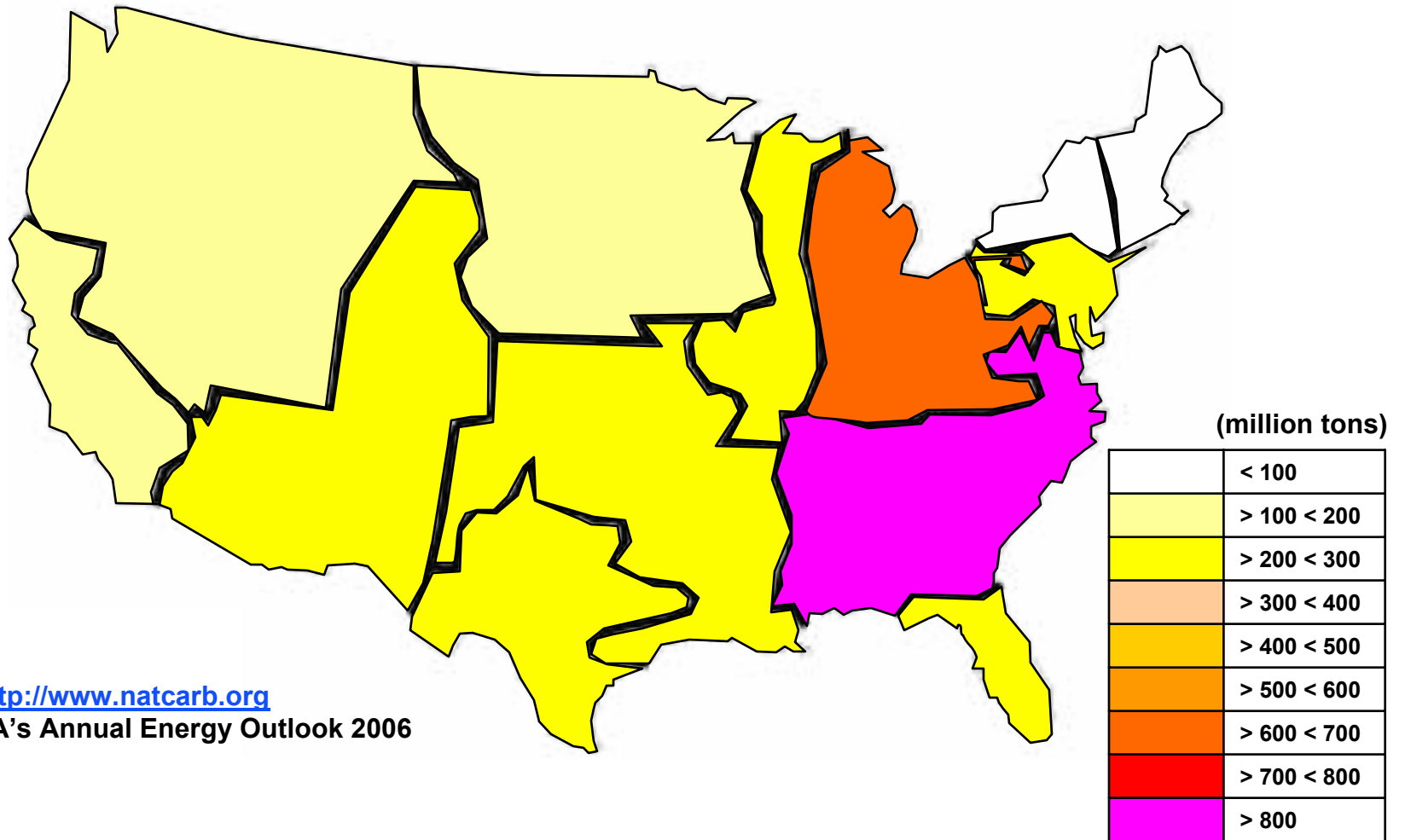
# 2025 CO<sub>2</sub> Forecast



Source: <http://www.natcarb.org>  
:EIA's Annual Energy Outlook 2006



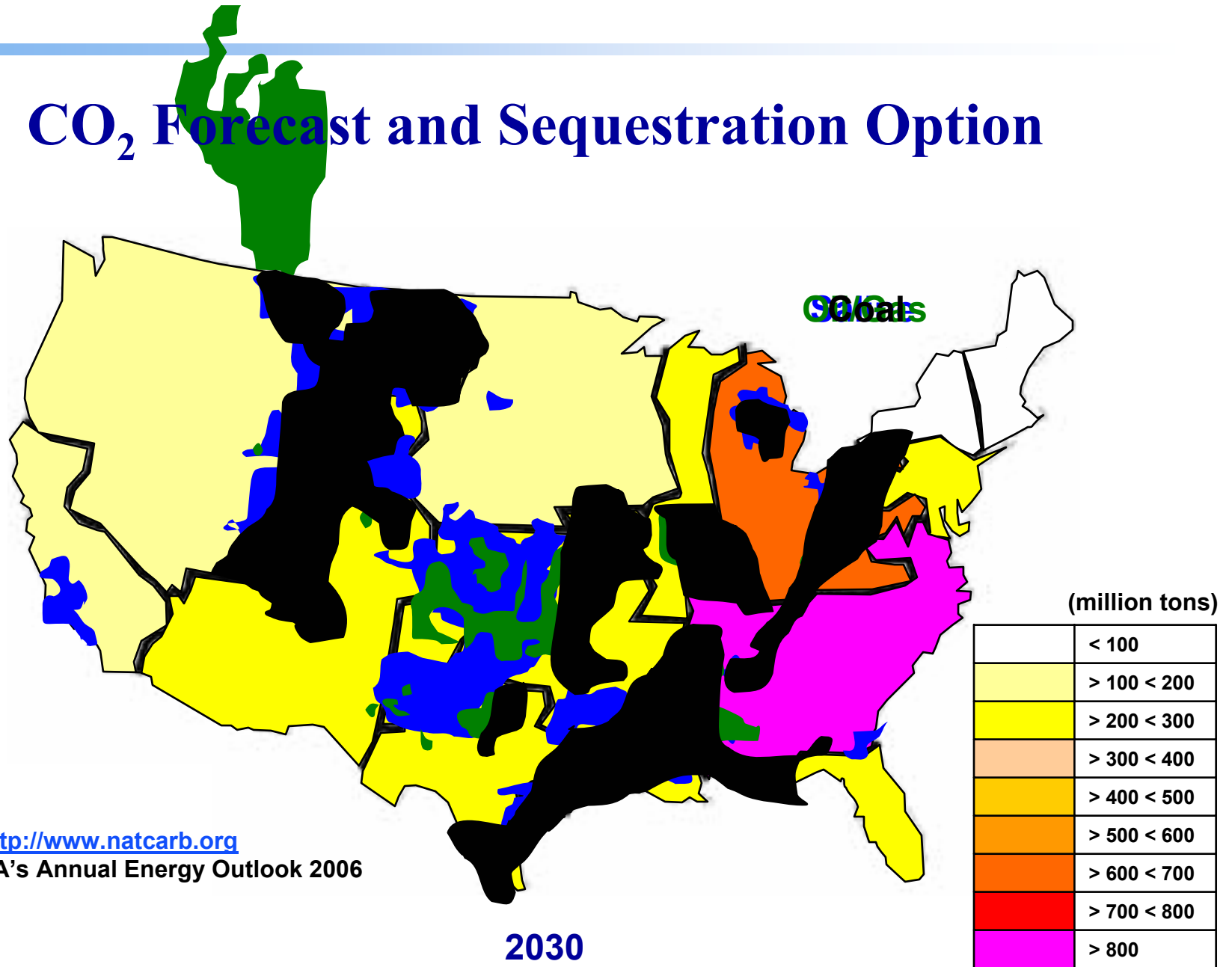
# 2030 CO<sub>2</sub> Forecast



Source: <http://www.natcarb.org>  
:EIA's Annual Energy Outlook 2006



# CO<sub>2</sub> Forecast and Sequestration Option



Source: <http://www.natcarb.org>  
:EIA's Annual Energy Outlook 2006



## Closing Thoughts

- Target market consists of all Phase 1 and 2 boilers larger than 300 MW and less than 35 years old (184 GW).
- The existing coal fired fleet produces 66% of the U.S. power sector CO<sub>2</sub> emissions and 75% of all CO<sub>2</sub> emissions from coal based power generation, at least to 2030.
- CCS has implied implications to industries supporting the power sector which need to be recognized and further analyzed.
- Post Combustion cycles whether existing or advanced cycles will be a significant part of the power generation sector for the foreseeable future.

Focusing R&D to those units likely to adopt CCS will increase the likelihood of having CO<sub>2</sub> control technologies commercially available if needed.



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# Acknowledgements

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# Questions ?

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